International Efforts in Doctoral Reform

Doctoral reforms in European and Asian countries are strengthening the university sector to become an explicit component of national innovation systems. The goals are to develop the capacity for breakthrough research leading to innovative products and successful markets, to stem "brain drain," and to attract top scientists to the country (NSF/INT 2000). Doctoral reforms also include providing national universities with more autonomy in hiring faculty and governance of academic programs and providing additional funds. International networks of universities share curriculum development and distance education.

Asian countries are using various mechanisms to improve the quality of doctoral programs and to upgrade equipment and facilities for academic research. World-class facilities often require international partnerships (Bagla 2000). For example, the Indian Institute of Technology (IIT) in Delhi is partnering with the International Business Machine research center on its campus for graduate research opportunities and exchange of faculty. In China, Shanghai's Fudan University and Bell Labs have a joint laboratory for software development and information technology (IT) (*China Daily* 2001b). In addition, research parks throughout Asia are concentrating high-technology industries next to top universities to attempt to create a "Silicon Valley." For example, Beijing's research park includes Peking University, the Chinese Academy of Sciences, and 4,000 high-technology enterprises (*China Daily* 2001a).

European countries are experimenting with doctoral reforms that prepare students not only to increase the store of basic science but also to apply knowledge to innovative technologies and find solutions to the problems confronted by society (Carlson 2001). Doctoral reform in France brings university research programs closer with the network of national laboratories (CNRS). For example, the CNRS Laboratory of Material Physics and two university labs are forming a Materials Center to be part of a large research complex outside Rouen (Carlson 1999).

Doctoral reforms in Europe also include international partnerships to create centers of excellence, some through the EU and some trans-Atlantic centers. The centers of excellence are designed both to improve the quality of research and to stem brain drain to other countries. For example, the University of Cambridge in Cambridge, England, and the Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts, are collaborating on the Cambridge-MIT Technology Institute. These two leading research universities will develop common courses and exchange faculty and students (Tugend 1999). A second MIT partnership, the MIT MediaLabEurope in Dublin, will build on Ireland's strength in computer sciences to become a center of excellence in IT for Europe (Birchard 2001).

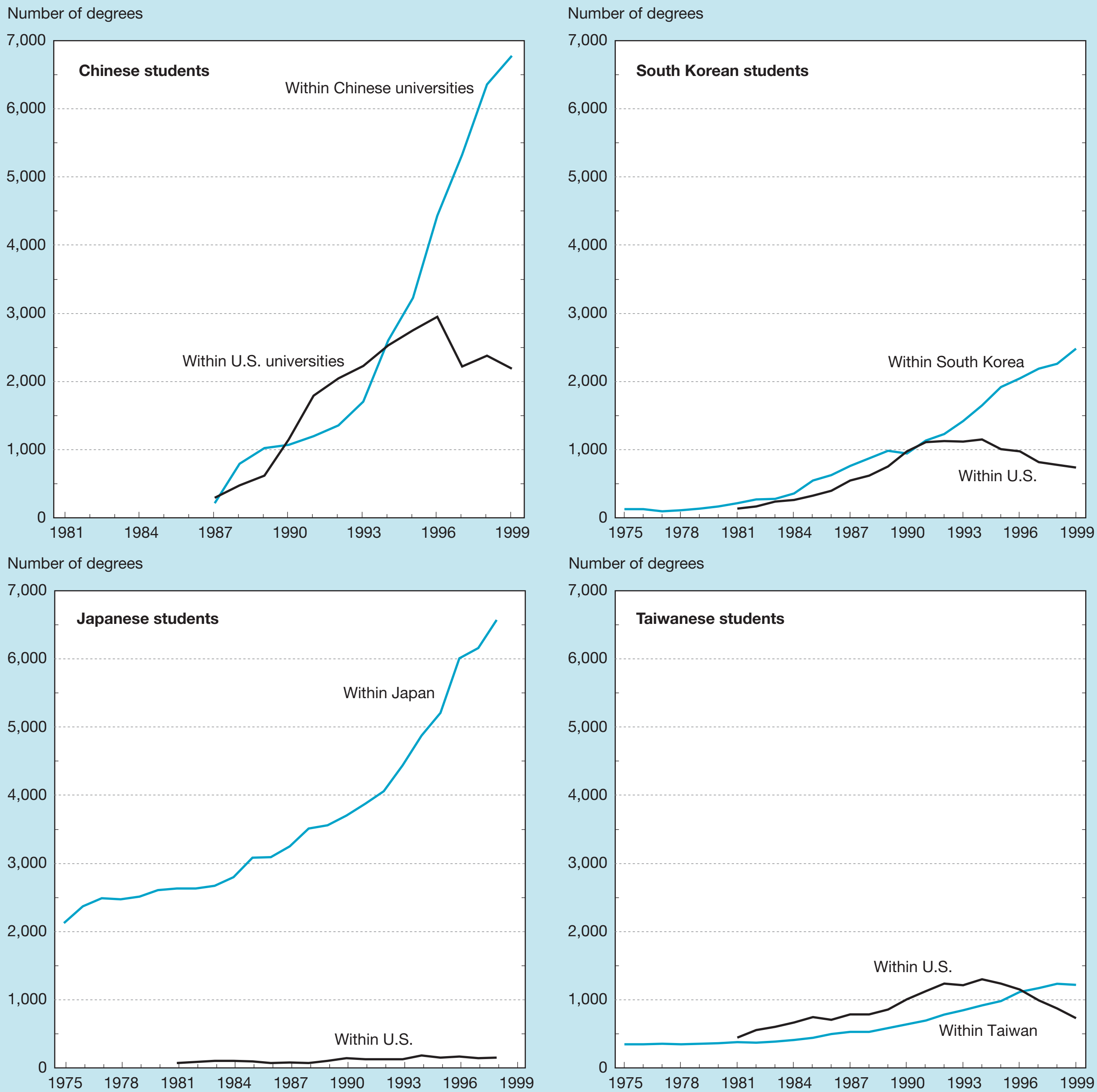
Countries and other places are using various funding sources, either public or private, to upgrade equipment and facilities. For example, Taiwan is publicly funding infrastructure improvements, as are industrialized countries such as Japan and those within the European Union. The U.K. government has recently committed large funds to improve deteriorating facilities and to raise stipends for doctoral students (Stone 2000; Urquhart 2000). China has used international funding sources to improve higher education (Hayhoe 1989) and is assisting the top universities in becoming financially independent through their partnerships with high-technology industries (China Daily 2001b). Hong Kong and South Korea have built science and technology (S&T) universities with business donations. The philanthropy of Indian scientists and engineers in the United States with successful companies is upgrading the IIT's facilities and creating new S&T universities in India (Goel 2000; Bagla 2000).

Conclusion

Students in the United States are as interested in studying some fields of science as they were in the past, but the declining level of interest in engineering and physical sciences still raises national concern. From 1975 to 1998, approximately one-third of all bachelor's degrees were earned in S&E fields. However, the distribution among natural sciences, social sciences, and engineering has changed. The approximately 12 percent of degrees earned in natural sciences are not as evenly distributed across physical and biological sciences as in previous decades. The number of degrees earned in biological sciences continues to increase, whereas the number earned in other natural sciences is dropping off. Engineering degrees, which represented 8 percent of all bachelor's degrees awarded in 1986, slowly dropped to 5 percent of all bachelor's degrees awarded in 1998. In addition, other countries award a higher percentage of bachelor's degrees in S&E fields; among European and Asian countries, the average is about 40 percent and it is considerably higher for some emerging Asian countries.

The United States has programs to increase access to S&E education for groups that were formerly underrepresented in S&E fields. Because these groups represent the growing segment of the population in the United States, an adequate future workforce will require that minorities choose careers in S&E. To date, modest progress has been made toward increasing the proportion of these minority college-age populations earning NS&E degrees. In 1998, among whites, the ratio of

Figure 2-31.
Doctoral S&E degrees earned by Asian students at home universities and U.S. universities: 1981–99



NOTES: Chinese degree data not available for earlier years. U.S. data include foreign doctoral recipients on either permanent or temporary visas.

See appendix tables 2-39 and 2-41.

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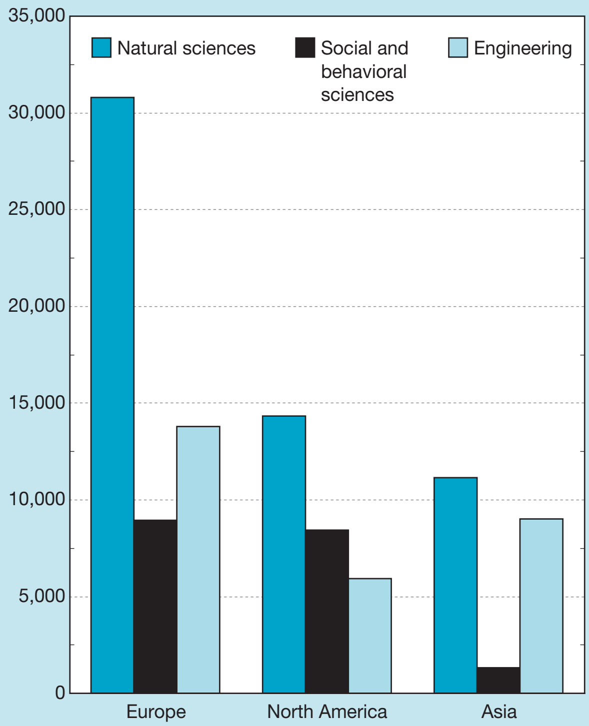
NS&E degrees to the college-age population was 6 per 100. Among underrepresented minorities, the ratio was less than half that of whites.

Further research is needed to quantify the increasing access to S&E education outside traditional higher education institutions. That is, what is the effect of nondegree programs in engineering and IT completed in the workplace through distance education and certificates?

This chapter discussed indicators of expanding access to S&E education in several world regions and modest expansion of access to minority groups within the United States. Many countries have significantly increased the proportion of their college-age population earning first university degrees in NS&E fields. In addition, they have expanded their institutional capacity for S&E graduate programs and doctoral education. This expansion indicates a share-shift in the proportion of S&E doc-

Figure 2-32.
Doctoral S&E degrees in Europe, North America, and Asia: 1999



NOTE: Natural sciences include physics, chemistry, astronomy, and biological, agricultural, earth, atmospheric and ocean sciences, as well as mathematics and computer sciences.

See appendix table 2-42 for countries and economies included in Europe, North America, and Asia.

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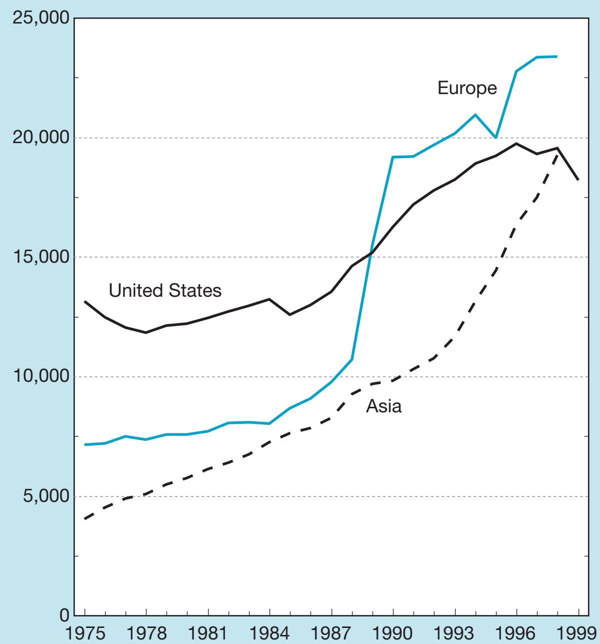
Figure 2-33.
Doctoral NS&E degrees in the United States, Europe, and Asia: 1975–99



NOTES: Natural sciences include physics, chemistry, astronomy, and biological, agricultural, earth, atmospheric and ocean sciences, as well as mathematics and computer sciences. Europe includes France, Germany, and the United Kingdom. Asia includes China, India, Japan, South Korea, and Taiwan.

See appendix tables 2-39, 2-40, and 2-24.

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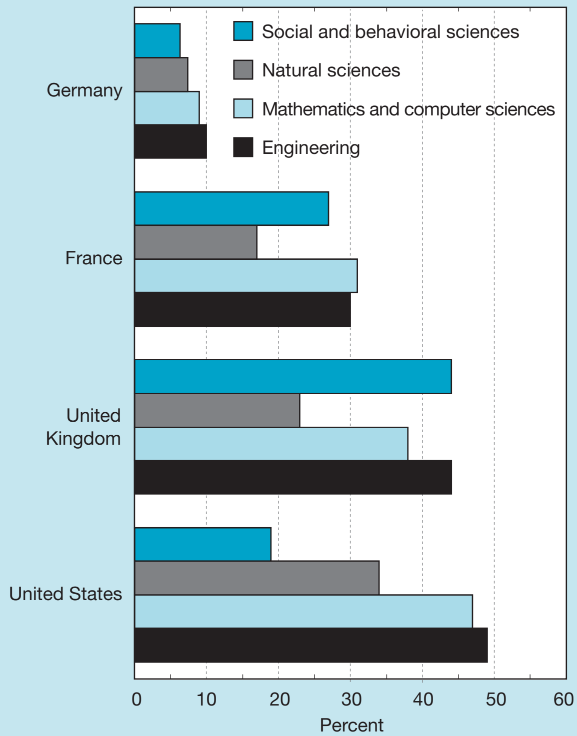
toral degrees earned outside the industrialized countries. The challenge to the scientific leadership of the United States and to corporate R&D[9] from this share-shift is to devise effective forms of collaboration and information exchange to benefit from, and link to, the expanding proportion of science performed abroad. Measures of collaboration in international coauthorship of scientific articles may be an important indicator for monitoring the globalization of science. For example, the degree to which international coauthorship increases or decreases could indicate how the United States is staying in touch with expanded research abroad.

Several advanced industrial countries are also expanding recruitment of foreign S&E graduate students to maintain and strengthen their academic R&D efforts, considered to be of increasing importance to innovation (Porter and Stern 1999). Little evidence suggests that other countries are competing with graduate schools in the United States in the recruitment of foreign S&E students. The number of foreign graduate students is increasing in universities in the United States and in several other countries. Small shifts in graduate students in Asia entering Japanese or Australian universities may occur because of proximity and active recruitment by those countries. There are also small downward shifts in the number of foreign graduate students to universities in the United States from some traditional feeder countries and economies that have expanded their graduate programs, such as South Korea and Taiwan.

Because mobility of people is the main mechanism for technology transfer, the flow of foreign students abroad and reverse flow of students back to their home countries provide an opportunity for S&T development. Whether S&E education abroad eventually contributes to the home country depends on its S&T policy and commitment to employing highly skilled professionals. China and many other developing countries have shown that they need not be able to offer employment to their scientists and engineers educated abroad to receive their scientific advice on development schemes or research directions (Meyer 2001). Research is needed on the appropriate mix of foreign S&E doctoral recipients who "stay abroad" and "return home" for mutual benefit to the host and sending countries. The beneficial mix of immediate and delayed returns and the variety of cooperative activities associated with reverse flow are likely to differ for individual countries, regions, and stages of development.

[9]See, for example, John E. Pepper, Chairman of the Board, The Procter & Gamble Company, "National Benefits from Global R&D," Industrial Research Institute Annual Meeting. Williamsburg, VA, May 26, 1999.

Figure 2-34.
Doctoral S&E degrees earned by foreign students in selected countries, by field: 1999



NOTES: U.S. data include those on permanent and temporary visas. Natural sciences include physics, chemistry, astronomy, and earth, atmospheric, ocean, biological, and agricultural sciences.

See appendix table 2-45. *Science & Engineering Indicators – 2002*

Text table 2-16.
Foreign S&E doctoral recipients in France who returned home, by field: 1998

Field	Total recipients	Percentage who returned
Natural sciences	672	28
Mathematics and computer sciences	262	17
Agriculture	37	5
Social sciences	262	44
Engineering	551	20

NOTE: Natural sciences include physics, chemistry, astronomy, and biological, agricultural, earth, atmospheric, and ocean sciences.

SOURCE: Government of France, Ministère de l'Éducation Nationale, de la Recherche, et de la Technologie, *Rapport sur les Études Doctorales* (Paris, 2000).

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